Indian J. Phys. 74B (6), 411-414 (2000)

RAPID COMMUNICATION

I J P B
an international journal

Airglow emission of OH (7,2) and OH (8,3) band emissions during night at Calcutta

D Bhaumik[1], J N Chakravorty[2*], S K Midya[2,3] and S C Chakraborty[4]

[1]Department of Physics, Ramakrishna Mission Residential College, Narendrapur, Calcutta-700 103, India

[2]Centre for Space Physics, 114/V/1A, Raja S C Mullick Road, Calcutta-700 047, India

[3]Department of Physics, Serampore College, Serampore, Hooghly-712 201, West Bengal, India

[4]Department of Physics, Jadavpur University, Calcutta-700 032, India

Received 31 August 2000 accepted 16 October 2000

Abstract Night airglow emission of OH (7,2) and OH (8,3) bands at Calcutta are presented. These types of variation are explained from their excitation mechanisms

Keywords Airglow emission, OH (7,2) and OH (8,3) bands

PACS No. : 94 10.Rk

1. Introduction

Light is observed to come from upper atmosphere in a moonless clear night sky. About 40% of this light is produced by the self-luminescence of atmospheric atoms and molecules. This light is called airglow.

The atoms and molecules of particles present in the upper atmosphere, absorb solar energy during day time. The absorbed energy is utilised in dissociating, exciting and ionizing atmospheric particles. Various collisional processes among these particles occur which lead to the excitation of these particles and then radiations are emitted from them.

Variation of intensity of airglow, originating from the upper atmosphere, is due to the variation of atomic and molecular concentrations of the atmosphere during different seasons.

OH (7,2) band (6862 Å) and OH (8,3) band (7275 Å) are two important emissions of night airglow spectrum. The purpose of this paper is to study the variations of intensity of these emissions during night. Theoretical explanation of these types of variations are also offered. The results of such investigations have important applications in studying the ozone depletion phenomena occurring in the upper atmosphere.

2. Experimental arrangement

The observations are taken by the usual form of Dunn Marning type photometer. Detailed experimental arrangement has been reported earlier [1–3]. A brief description of the arrangement is mentioned for convenience. Light is allowed to fall on the cathode of a photomultiplier tube after passing through a narrow band pass filter. The output photocurrent was measured by a nanoammeter in the two filters respectively at an interval of approximately 15 minutes.

The observations were taken from the roof of Ramakrishna Mission Residential College, Narendrapur (22°35' N, 88°21' E) near Calcutta during the period from February 1996 to May 1998.

3. Observations and analysis

It has been reported in our previous paper [4] that intensity of OH (7,2) band decreases exponentially after sunset during

*Corresponding Author

evening twilight period. Again in another communication [5], we have presented the exponential rise of OH (7,2) band during morning twilight period at Calcutta. This paper presents the variation of intensity of OH (7,2) band and OH (8,3) band at Calcutta during night time.

Results of a few observations made in dark clear moonless nights are shown in Figure 1. In most of the nights, the

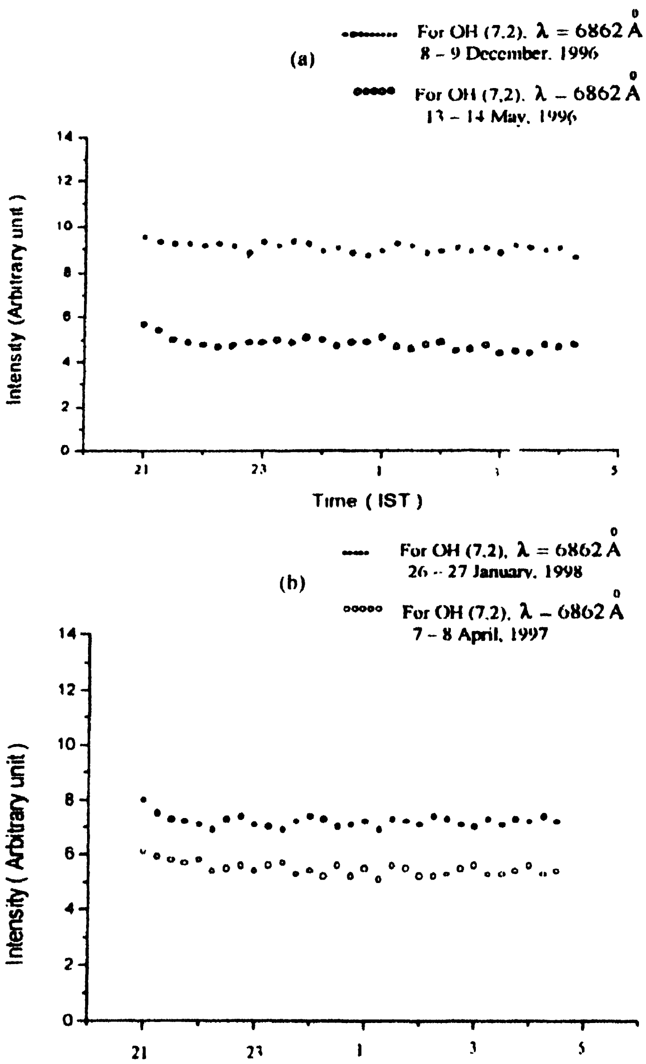

Figure 1(a, b). Intensity variation of OH (7,2) band during night at Calcutta

variation of intensity of OH (7,2) band follow the trend of variation as shown in Figure 1. In a very few nights, the variation of intensity of OH (7,2) band follow slightly different trend as shown in Figure 2. It is clear from Figures 1(a) and 1(b) that night airglow emission of OH (7,2) almost remains constant throughout the night. It is found from Figure 2 that the intensity of night airglow emission of OH (7,2) remains constant initially and then shows a slight increase during the later part of the night. Intensity of night airglow emission of OH (8,3) band also remains constant in most of the nights as evident from Figures 3(a) and 3(b). In a very few nights, intensity of OH (8,3) band during night

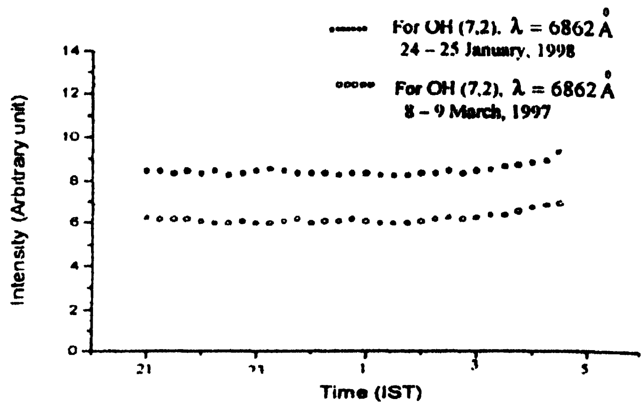

Figure 2. Intensity variation of OH (7,2) band showing a different trend during night at Calcutta

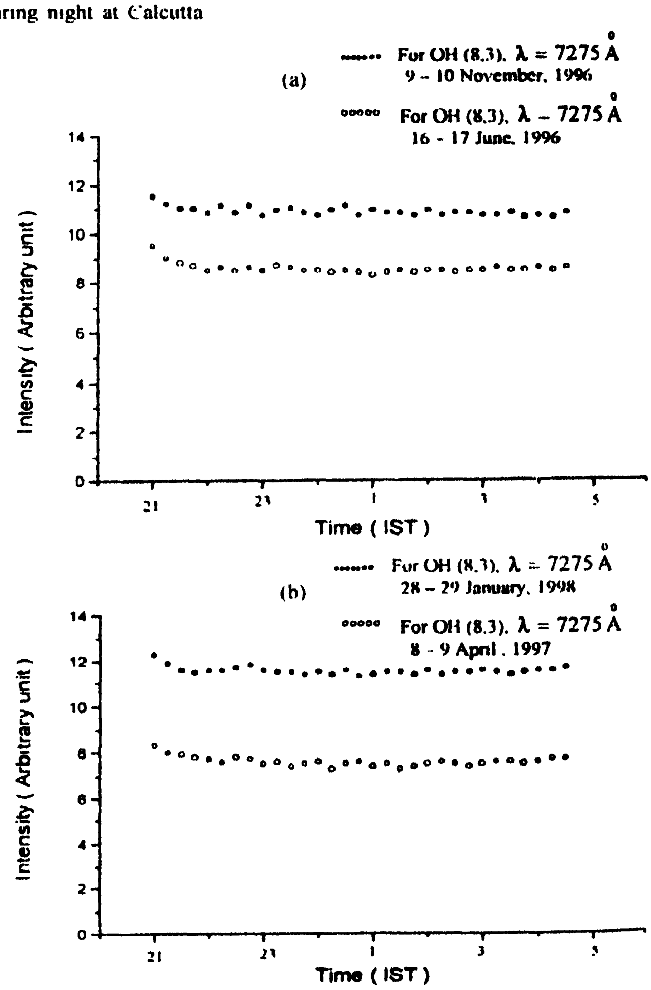

Figure 3(a, b). Intensity variation of OH (8,3) band during night at Calcutta

time has been found to remain constant initially and then increases during the later part of the night (Figure 4). From normal intensity variation curves of OH (7,2) and OH (8,3) bands, it can be concluded that the nature of variation of these two emissions remains nearly same [6] and the intensity remains almost constant throughout the night interval.

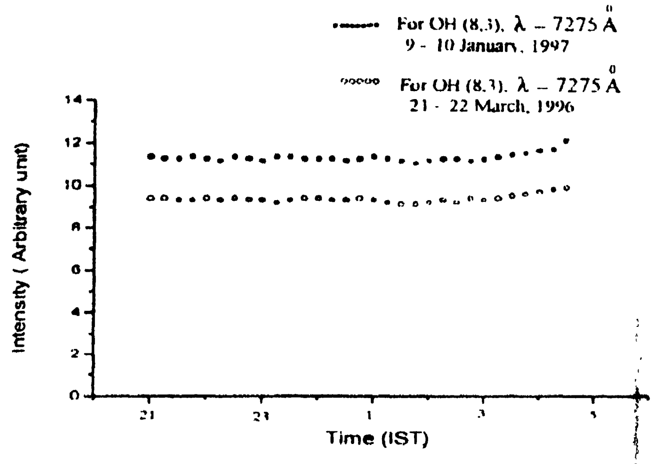

Figure 4. Intensity variation of OH (8.3) band showing a different trend during night at Calcutta

The volume emission rate of hydroxyl bands is calculated following Bates and Nicolet [7] mechanism and the results are given in Table 1. It is clear from the table that the volume

Table 1. Volume emission rate of OH band at different heights

Height (in km)	Number density		Volume emission rate n
	$n[O_3] \times 10^{8}$	$n[H] \times 10^{8}$	$[OH]^{*} \times 10^{5}$ cm^{-3} sec^{-1}
75	3.2	0.51	3.87
76	2.8	2.1	13.94
77	2.5	3.7	21.93
78	2.1	5.4	26.88
79	1.8	7.0	29.86
80	1.4	8.6	28.55
81	1.3	8.3	25.57
82	1.2	7.9	22.47
83	1.16	7.7	20.90
84	1.08	7.2	18.43
85	1.00	6.9	16.35
86	1.02	5.9	14.26
87	1.04	5.1	12.57
88	1.06	4.1	10.30
89	1.08	3.2	8.19
90	1.10	2.3	6.00

emission rate of hydroxyl bands is maximum near about 80 km. The number densities of different constituents used for calculation are taken from Jacchia [8] and Krassovsky [9].

Excitation mechanism of OH bands are as follows :

(a) Bates and Nicolet mechanism [7]

$$O + O_2 + M \xrightarrow{K_1} O_3 + M,$$

$$O_3 + H \xrightarrow{K_2} O_2 + OH^{*},$$

$$OH^{*} \longrightarrow OH + h\nu,$$

where M is the third body required to carry away the excess energy and momentum.

The rate constants are taken from Stuhl and Niki [10] and Nicolet [11] :

$$K_1 = 1.5 \times 10^{-34} \exp(445/T_i)\,\mathrm{cm^6\,s^{-1}}\ [10]$$

$$K_2 = 1.5 \times 10^{-12}\sqrt{T}\,\mathrm{cm^3\,s^{-1}}\ [11]$$

(b) Krassovsky mechanism [12]

$$O_2 + O + M \xrightarrow{K_3} O_3 + M,$$

$$O + O_3 \xrightarrow{K_4} O_2 + O_2,$$

$$O_2 + H \longrightarrow OH + O,$$

$$OH^{*} \longrightarrow OH + h\nu.$$

The rate constants are taken from Krassovsky [9] :

$$K_3 = 1.5 \times 10^{-33}\ \mathrm{cm^6\ s^{-1}},$$

$$K_4 = 1.0 \times 10^{-9}\ \mathrm{cm^3\ s^{-1}}.$$

(c) Breig mechanism [13]

$$H + M + O_2 \xrightarrow{K_5} HO_2 + M,$$

$$HO_2 + O \xrightarrow{K_6} OH^{*} + O_2,$$

$$OH^{*} \longrightarrow OH + h\nu.$$

The rate constants are taken from Gattinger [14] :

$$K_5 = 3.3 \times 10^{-33} \exp(800/T)\ \mathrm{cm^6\ s^{-1}},$$

$$K_6 = 1.5 \times 10^{-12}\sqrt{T}\ \mathrm{cm^3\ s^{-1}}\ \text{(Gattinger)}$$

The concentration of $n(O)$, $n(O_2)$, $n(O_3)$ and $n(N_2)$ are taken from Jacchia [8] and $n(H)$ are taken from Krassovsky [9].

Neglecting the quenching term, the rate of production of $n(OH)^{*}$ according to Bates-Nicolet theory is given by

$$n(OH)^{*} = K_2\, n(O_3)\, n(H).$$

Volume emission rate of OH band for different height have been calculated as usual from above equation and given in Table 1. The values obtained agrees well with the result of Midya [15].

Calculation of $n(OH)^{*}$ from above equation at height 80 km at temperature 250 K has been shown below as an example.

$$n(O_3) = 1.4 \times 10^{8},$$

$$n(H) = 8.6 \times 10^{8},$$

$$T = 250\ \mathrm{K},$$

$$K_2 = 1.5 \times 10^{-12}\sqrt{250},$$

$$n(OH)^{*} = 28.55 \times 10^{5}\ \mathrm{cm^{-3}\ sec^{-1}}\ \text{(calculated value)}.$$

It is observed from Table 1 that the volume emission rate of OH band increases with altitude and is maximum at 80 km height. It is observed that the shape and peak altitude agree well with the result of Rocket borne measurements of the altitude distribution of hydroxyl bands, night glow emission performed by Evans *et al* [16]. It is shown by

Midya [15] that Bates and Nicolet mechanism is predominant mechanism for OH band emission. In another communication, Midya *et al* [17], have shown by statistical analysis that Bates-Nicolet mechanism is the appropriate excitation process of OH band emission.

4. Conclusion

From Bates-Nicolet mechanism, it is observed that intensity of OH bands depend on O_3 concentration. Shimazaki and Laird [18] showed that O_3 concentration at about 85 km remains almost constant throughout night after a rapid post sunset rise. This is also evident from the results of our observations as shown in the Figures 1 and 3. Thus, intensity of OH bands is expected to remain constant throughout night interval.

In this connection, it may be mentioned that OH band intensity will be depleted with the depletion of O_3 concentration. WMO bulletin confirms that O_3 is declining everywhere by smaller amount but dramatic decrease of O_3 concentrations take place at Antarctica during spring time [19,20]. The nature of variation of OH band with depletion of O_3 concentration is shown in Midya's previous communications [15]. Rao *et al* [21] also mentioned that OH band intensity would be affected with variation of O_3 concentrations. Thus, it can be concluded that the results of the measurement of hydroxyl band intensity presented in this paper will be extremely helpful in calculating and studying ozone depletion.

Acknowledgment

The authors are grateful to the Principal of Ramakrishna Mission Residential College, Narendrapur for providing facilities for conducting experimental observations.

References

[1] S N Ghosh and S K Midya *Indian J Radio Space Phys.* **15** 53 (1986)

[2] S K Midya, G Tarafdar and T K Das *Earth, Moon and Planets* (Netherlands) **63** 199 (1993)

[3] S K Midya and S N Ghosh *Earth, Moon and Planets* (Netherlands) **66** 145 (1994)

[4] D Bhaumik, J N Chakravorty, S K Midya and S R Chakraborty *Earth, Moon and Planets* (Netherlands) **74** 115 (1996)

[5] D Bhaumik, J N Chakraborty, S K Midya and S R Chakraborty *Earth, Moon and Planets* (Netherlands) **75** 169 (1996)

[6] V R Rao and P V Kulkarni *Indian J Radio Space Phys* **1** 181 (1972)

[7] D R Bates and M Nicolet *J Geophys Res* **55** 301 (1950)

[8] L G Jacchia *SAO Special Report No 375* (Smithsonian Institute Astrophysical Observatory, Cambridge, Massachusetts) (1977)

[9] V I Krassovsky *Ann Geophys* **27** 211 (1971)

[10] F Stuhl and H J Niki *Chem Phys* **55** 3943 (1971)

[11] M Nicolet *Ann Geophys* **26** 531 (1970)

[12] V I Krassovsky *On the Detection of the Infrared Night Airglow and Aurrora* eds S B Armstrong and A Daglarno 193 (1956)

[13] F L Breig *Planet Space Sci* (GB) **18** 1271 (1970)

[14] R L Gattinger *The Radiating Atmosphere* ed B M McCormac (Dordrecht D Reidel) p 51 (1971)

[15] S K Midya *Earth, Moon and Planets* (Netherlands) **65** 1 (1994)

[16] W F J Evans, E J Llewellyn and A Jones Vallance *Can J Phys* **1288** 51 (1973)

[17] S K Midya, P K Jana and S K Mondal *Indian J Phys* **72B** 387 (1998)

[18] T Shimazaki and A R Laird *Radio Sci* **7** 23 (1972)

[19] R D Bojkov *WMO Bulletin* **41** 171 (1992)

[20] S N Ghosh and S K Midya *Indian J Phys* **68B** 473 (1994)

[21] V R Rao and P V Kulkarni *Indian J Pure Appl Phys* **6** 644 (1971)